ISSN: 1231-4005
e-ISSN: 2354-0133
DOI: 10.5604/12314005.1138635

RESEARCHES NOVEL MATERIALS ON THE PISTONS WITH LOW HYSTERESIS TO COMBUSTION ENGINES

Barbara Sieminska

Institute of Aviation
Krakowska Av. 110/114, 02-256 Warsaw, Poland
tel.: +48 22 8460011, fax: +48 22 846 4432
e-mail: barbara.sieminska@ilot.edu.pl

Zenon Slawinski

Lublin University of Technology
36Nadbystrzycka Street 20-618 Lublin Poland
tel.: +48 81 53 84 258, fax: +48 81 53 84 258
slavex@pixel.org.pl

Abstract

The researches were carried out at the use of the precise dilatometer of the firm BAHR 802/801. The device makes possible the registration of changes of measurements of the sample in the function of the temperature. Measurements in the simpler and differential are possible. Heating and cooling is performed in the special device, which realizes the programme temperature, controlled computer.

Changes of dimensions are measured with an inductive sensor. Samples were placed in the quartz-pipe and changes of their length were transferred by quartz-rods. The temperature of tested material was measured by means of the Pt-PtRh thermocouple.

Material on the pistons has a fundamental meaning for the value of the clearances between the cylinder and the piston. Too small clearness between the piston and cylinder on the cold engine cannot be applying, because during the work of an engine it would be able to occur seizing of an engine. From here, also the large resistance on seizing of material of the piston is essential. Investigated composite materials performed based on piston-silumins AK12 and AK18 in which a composite addition was silicon carbide (SiC) and ferric sulphide (FeS).

Keyword: *combustion engines, engine pistons, composite alloy, thermal expansion, hysteresis*

1. Introduction

In the last period the problems of the development of combustion engines dominate works targeting: the limitation of the emission of harmful components of exhaust gases (the carbon monoxide, hydrocarbons, nitrogen oxides, particulate matters), decreasing of the emission carbon dioxide (what consequently makes for decreases fuel consumptions) , increasing durability and dependability work of engines. Essential manner connected with improvement of system-solutions pistons. The most essential influence pistons is reflected in fuel consumption (coefficient of friction and working clearances), the emission of components of harmful exhaust gases (working clearances, coefficient of thermal expansion, the hysteresis of the coefficient of thermal expansion, the heat exchange between combustion chamber and the cooling fluid), noise level and the vibration.

2. The problems of piston-materials for combustion engines

The kind of material on the pistons has crucial role for the correct work of an internal combustion engine. Material on the pistons has a fundamental meaning for the value of the clearances between the cylinder and the piston. Too small clearness between the piston and cylinder on the cold engine cannot be applying, because during the work of an engine it would be able to occur seizing of an engine. From here, also the large resistance on seizing of material of the piston is essential. Investigated composite materials performed based on piston-silumins AK12 and AK18 in which a composite addition was silicon carbide (SiC) and ferric sulphide (FeS). The composite with additives of silicon carbide characterized with a very high resistance on seising and low coefficient of friction, however the composite with additives of ferric sulphide characterized first of all with the low coefficient of friction and the high resistance on seizing.

3. Test results

The researches were carried out at the use of the precise dilatometer of the firm BAHR 802/801. The device makes possible the registration of changes of measurements of the sample in the function of the temperature. Measurements in the simpler and differential are possible. Heating and cooling is performed in the special device, which realizes the programme temperature, controlled computer. Changes of dimensions are measured with an inductive sensor. Samples were placed in the quartz-pipe and changes of their length were transferred by quartz-rods. The temperature of tested material was measured by means of the Pt-PtRh thermocouple.

Fig. 1. presents the general view of the research equipment. Fig. 2 presents the view of the measuring-head of the extension.

Fig. 1. The general view of the research equipment

Fig. 2. The view of the measuring-head of the extension

Fig. 3. shows the course linear coefficient α thermal expansion α in the function temperature (T) during heating and cooling of the standard overeutectic silumin of coefficient α during the piston cooling equal to the coefficient α within the range temperatures 340^0C-300^0C and higher below temperatures 300^0C.

Fig. 4. shows the course of the linear coefficient α of thermal expansion α in the function of the temperature (T) during the heating and the cooling of the standard overeutectic silumin of greater coefficient α during the piston cooling than the coefficient α during heating.

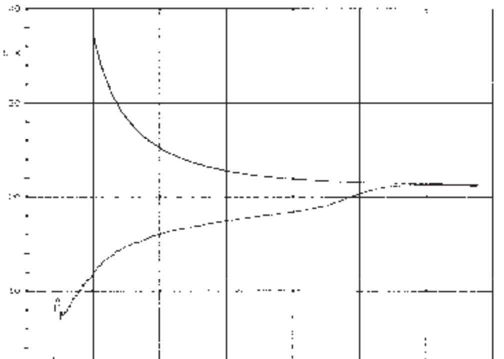


Fig. 3. The course linear coefficient α thermal expansion α in the function temperature (T) during heating and cooling of the standard overeutectic silumin of coefficient α during the piston cooling equal to the coefficient α within the range temperatures 340^0C-300^0C and higher below temperatures 300^0C

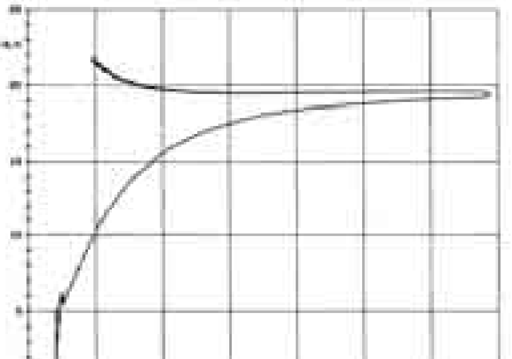


Fig. 4. The course of the linear coefficient α of thermal expansion α in the function of the temperature (T) during the heating and the cooling of the standard overeutectic silumin of greater coefficient α during the piston cooling than the coefficient α during heating

Fig. 5. shows the segment of the course of the linear coefficient α of thermal expansion *α* in the function of the temperature (T) during the heating of the standard overeutectic silumin (the characteristic phase transition within the range temperatures 170^0C-300^0C.

Fig. 6. shows the course of the relation of the increase of the dimension of the sample of the piston to the increase of the time $\Delta\lambda/\Delta\tau$ in the function of the temperature (*T)* during the heating and the cooling of the standard overeutectic silumin (the characteristic phase transition within the range temperatures 170^0C-300^0C.

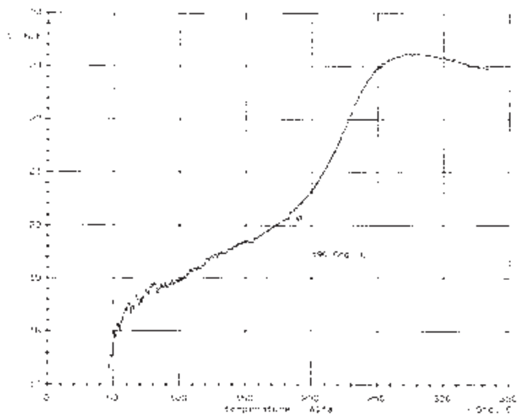


Fig. 5. The segment of the course of the linear coefficient α of thermal expansion α in the function of the temperature (T) during the heating of the standard overeutectic silumin (the characteristic phase transition within the range temperatures 170^0C-300^0C

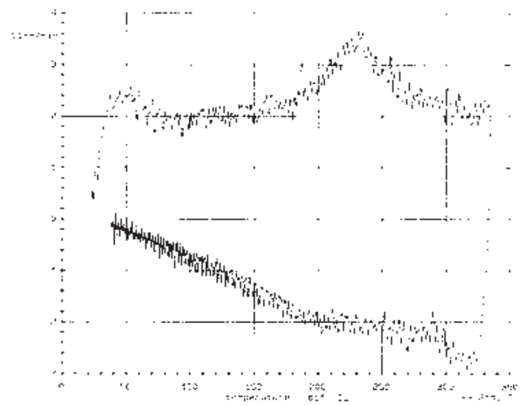


Fig. 6. The course of the relation of the increase of the dimension of the sample of the piston to the increase of the time $\Delta\lambda/\Delta\tau$ in the function of the temperature (T) during the heating and the cooling of the standard overeutectic silumin (the characteristic phase transition within the range temperatures 170^0C-300^0C

Fig. 7. shows the course of the linear coefficient α of the thermal (in the function temperature (*T)* expansion during heating and cooling of the tested alloy of composite BS of the smaller coefficient α during the piston cooling than coefficient α during heating.

Fig. 8. shows the course of the relation of dimension increment of the sample of the piston to time increment, $\Delta\lambda/\Delta\tau$ in function temperature (*T)* during heating and cooling of the test alloy of composite BS of coefficient α presented on Fig. 7.

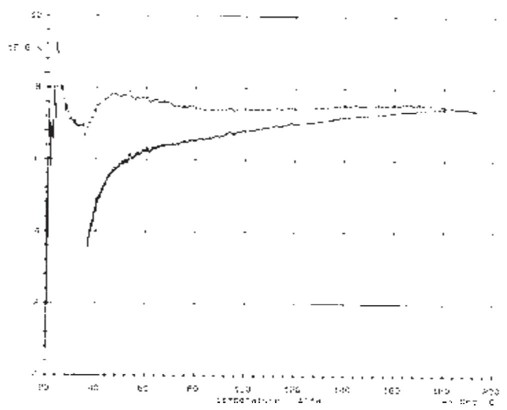
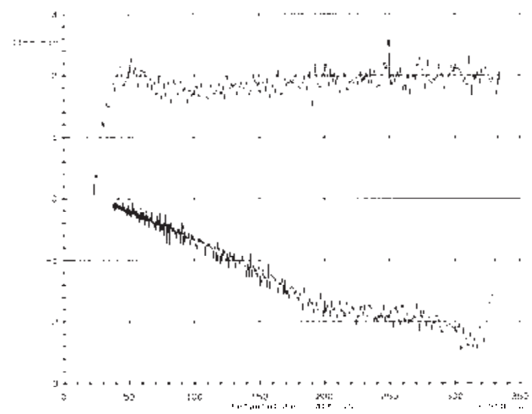


Fig. 7. The course of the linear coefficient α of thermal (in the function temperature (T) expansion during heating and cooling of the tested alloy of composite BS of the smaller coefficient α during the piston cooling than coefficient α during heating



. The course of the relation of dimension increment of the sample of the piston to time increment $\Delta\lambda/\Delta\tau$ in function temperature (T) during heating and cooling of the test alloy of composite BS of coefficient α presented on Fig. 7

Fig. 9. shows the course of the linear coefficient α of thermal expansion α in the function of temperature (*T)* during heating and cooling of the test alloy of composite BS of the lower coefficient α during the piston cooling to the temperature 180^0C and the smaller coefficient α during the piston cooling below temperatures 180^0C.

Fig. 10. shows the course of the relation of the increase of the dimension of the sample of the

piston to the increase of the time Δλ/Δτ in the function of the temperature (*T)* during heating and cooling of the test alloy of composite BS of the coefficient α presented on Fig. 9.

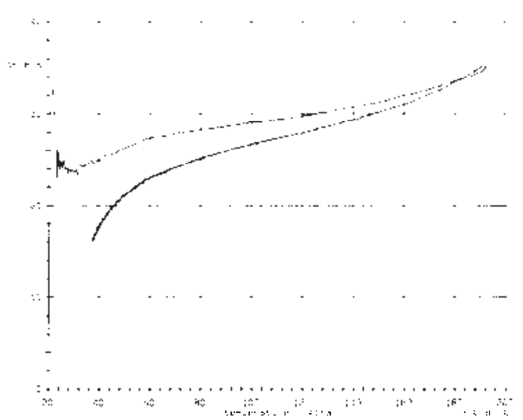


Fig. 9. The course of the linear coefficient α of thermal expansion α in the function of temperature (T) during heating and cooling of the test alloy of composite BS of the lower coefficient α during the piston cooling to the temperature 180^{0}C and the smaller coefficient α during the piston cooling below temperatures 180^{0}C C

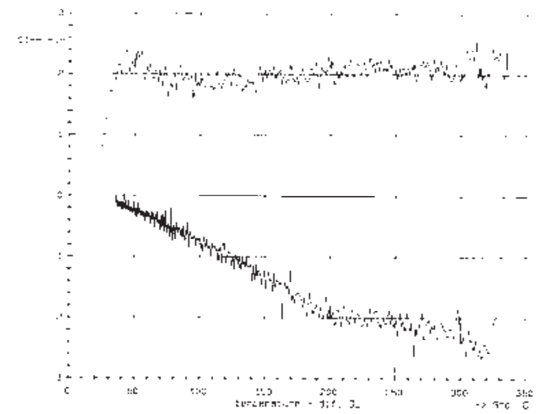


Fig. 10. The course of the relation of the increase of the dimension of the sample of the piston to the increase of the time Δλ/Δτ in the function of the temperature (T) during heating and cooling of the test alloy of composite BS of the coefficient α presented on Fig. 9

Fig. 11. Shows the course of the linear coefficient α of thermal expansion α in the function temperature (*T)* during heating and cooling of the test alloy of composite BS of the greater coefficient α during the piston cooling.

Fig. 12. Shows the course of the increase of the extension dimension of the sample of the piston (in the function temperature (*T)* during heating and cooling of the test alloy of composite BS of the greater increment of the extension during cooling.

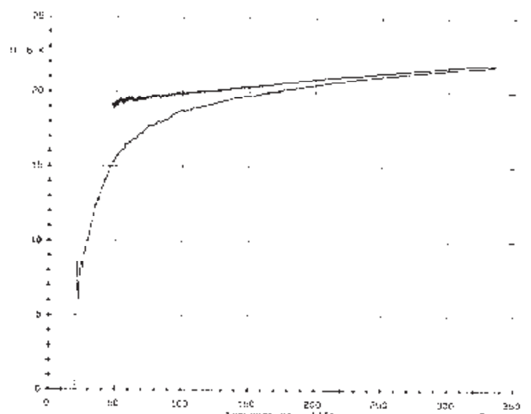


Fig. 11. The course of the linear coefficient α of thermal expansion α in the function temperature (T) during heating and cooling of the test alloy of composite BS of the greater coefficient α during the piston cooling

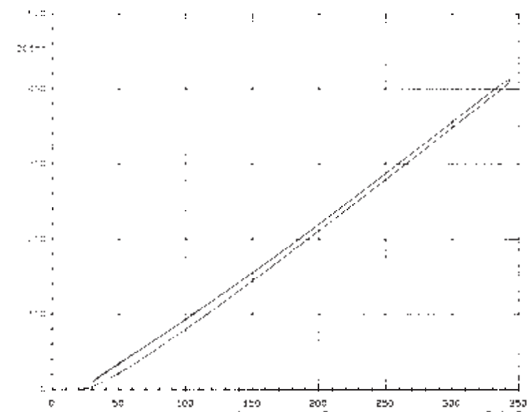


Fig. 12. The course of the increase of the extension dimension of the sample of the piston (in the function temperature (T) during heating and cooling of the test alloy of composite BS of the greater increment of the extension during cooling

Fig. 13. shows the example-course of the increase of measurements of the sample (the standard overeutectic silumin in the function of time of heating (*t)* at temperature 300^{0}C.

Fig. 14. shows the course linear coefficient α of thermal expansion α in the function of the temperature (T) during the heating and the cooling of the exploratory alloy of composite BS about the coefficient α during cooling near to the coefficient α during heating of the piston.

Fig. 15. shows the course linear coefficient α of thermal expansion α in the function temperature (T) during heating and cooling of the test alloy of composite BS of coefficient α

during cooling equal coefficient α during heating of the piston.

Fig. 16. shows the course of the relative extension in the function of time in the stabilization of the composite piston at the temperature 225^0C.

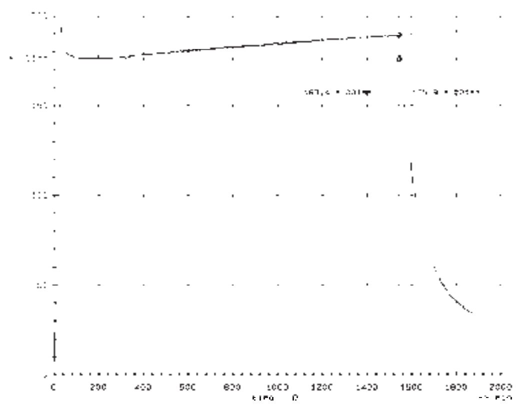


Fig. 13. The example-course of the increase of measurements of the sample (the standard overeutectic silumin in the function of time of heating (t) at temperature 300^0C

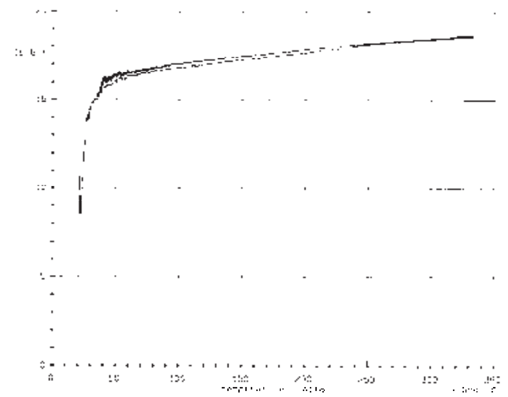


Fig. 14. The course linear coefficient α of thermal expansion α in the function of the temperature (T) during the heating and the cooling of the exploratory alloy of composite BS about the coefficient α during cooling near to the coefficient α during heating of the piston

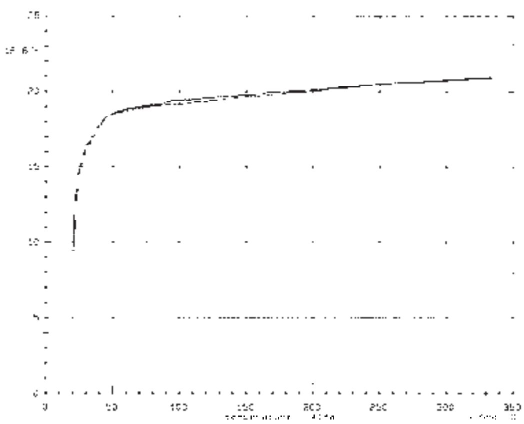


Fig. 15. The course linear coefficient α of thermal expansion α in the function temperature (T) during heating and cooling of the test alloy of composite BS of coefficient α during cooling equal coefficient α during heating of the piston

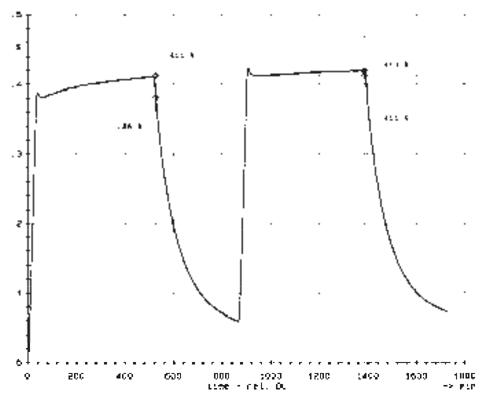


Fig. 16. The course of the relative extension in the function of time in the stabilization of the composite piston at the temperature 225^0C

7. Conclusions

During the heating and the cooling both increases of measurements, how {as} and diminutions appear.

The hysteresis of the coefficient α occurs during heating and cooling of the pistons, what is reflected by the change of constant dimensions of the pistons during their work in engines.

Under thermal loads, pistons can increase or decrease dimensions, whereat the character of these changes connected with temperature, to which the piston is warmed in the engine.

Within the range low operating temperatures of the pistons the change dispensations cannot appear. Within the range of high operating temperatures of the pistons in engines the change of dimension-pistons appear in most cases.

Established relationship became between temperature of material and with changes dimensions reaching in this material. Within the range low temperatures of the heat treatment, the proper stability does not receive, even during the very long of the heat treatment.

The receipt of the suitable dimension-stability of the pistons by means of two-grade heat treatment aging in the constant temperature is possible.

The hysteresis of the linear coefficient of thermal expansion α depends mainly from the kind of crystals of the silicon in the eutectic both in reference to newel alloy, as and standard.

On the value of the hysteresis of the coefficient α decides the state stress of solid solution.

The double-stage aging of an alloy in temperature 503 K and 483 K decrease considerably the hysteresis

Results of works can be used to decreasing of the clearances between the piston and cylinder, what can contribute to the increasing dependability of the work of the engine, decreasing of the emission of harmful components of exhaust gases, noise level reduction and vibration

In reference to investigated materials the critical temperature, above which appear changes dimensions contains within the range of 523 - 543 K.

References

[1] Jankowska-Sieminska, B., Jankowski, A., Slawinski, Z., *Composite Alloy for IC Engine Pistons,* Journal of KONES Powertrain and Transport, Vol. 17, No. 2, pp. 159-166, Warsaw2010.

[2] Jankowski, A., Pietrowski, S., Sieminska, B., Szymczak, T., *High-quality silumin on pistons of combustion engines*, Journal of KONES Internal Combustion Engines, Vol. 16, No. 4, pp. 563-573, Warsaw 2009.

[3] Jankowski, A., Sandel, A., *Exhaust Emission Reduction Problems of Internal Combustion Engines Fueled With Biofuels*, Journal of KONES Internal Combustion Engines 2003, Vol. 10,.No. 3-4, Warsaw 2003.

[4] Jankowski, A., Sandel, A., *Influence of Fuel Quality on Mixture Preparation and Exhaust Emissions from Diesel Engines with Common Rail System,* Journal of KONES Internal Combustion Engines 2003, Vol. 10, No. 3-4, Warsaw 2003.

[5] Jankowski, A., Sandel, A., Sęczyk, J., Siemińska-Jankowska, B., *Some Problems of Improvement of Fuel Efficiency and Emissions in Internal Combustion Engines,* Journal of KONES Internal Combustion Engines 2002, Vol. 9, 3-4, pp. 333-356 Warsaw 2002.

[6] Jankowski, A., Sieminska, B., Slawinski, Z., *The Resistance on Thermal Shocks of Combustion Engine Pistons,* FISITA Transactions, London 2007.

[7] Jankowski, A., *Some Aspects of Heterogeneous Processes of the Combustion Including Two Phases*, Journal of KONES Internal Combustion Engines, Vol. 12, No. 1-2, pp. 121-134, Warsaw 2005.

[8] Jankowski, A., *Study of the influence of different factors on combustion processes (Part two),* Journal of KONES Internal Combustion Engines, Vol. 16, No. 3, s. 135-140, Warsaw 2009.

[9] Jankowski, A., *Heat Transfer in Combustion Chamber of Piston Engines*, Journal of KONES Powertrain and Transport, Vol. 17, No. 1, pp. 187–198, Warsaw 2010.

[10] Jankowski, A., Jankowska, B, Slawinski, Z., *The Resistance on Thermal Shocks of Combustion Engine Pistons*, FISITA Transactions, London 2007.

[11] Jankowski, A., *Laser Research of Fuel Atomization and Combustion Processes in the Aspect of Exhaust Gases Emission,* Journal of KONES Powertrain and Transport, Vol. 15, No. 1, pp. 119–126, Warsaw 2008.

[12] Jankowski, A., Pietrowski, S., Sieminska, B., Szymczak, T., *High-Quality Silumin on Pistons of Combustion Engines,* Journal of KONES Powertrain and Transport, Vol. 16, No. 4, pp. 563–573, Warsaw 2009.

[13] Kuroishi, M., Kawaguchi, A., Inagaki, M., Torii, H., *Computational Method of Piston Structure and Lubrication Using Flexible Multibody Dynamics Technique,* FISITA2006 Proc. F2006P359, Yokohama Japan 2006.